

Applicant: Nestor RODRIGUEZ-AMAYA et al.  
Docket No. R.306166  
Preliminary Amdt.

**AMENDMENTS TO THE SPECIFICATION:**

Page 1, please add the following new paragraphs before paragraph [0001]:

[0000.2] CROSS-REFERENCE TO RELATED APPLICATIONS

[0000.4] This application is a 35 USC 371 application of PCT/DE 2004/002356  
filed on October 22, 2004.

[0000.6] BACKGROUND OF THE INVENTION

Please add the following new paragraph after paragraph [0001]:

[0001.2] This invention relates to an improved fuel injection valve for internal combustion engines.

Please add the following new paragraph after paragraph [0001.2]:

[0001.4] Description of the Prior Art

Please delete paragraph [0003].

Page 2, please replace paragraph [0007] with the following amended paragraph:

[0007] Because of the mechanical wear in the sealing region that occurs over the life of the magnet valve, the cone angles of the valve needle and the valve body become similar with increasing time in operation. From a linear seal (sealing edge) when the magnet valve is new, over the course of time in operation a flattened seal is created once the valve has been run in. Depending on the configuration of the surface structure of the sealing face that is established because of wear, high pressure  $[[p_{HP}]]$  **fluid** can get under this sealing face. Because of the transition from linear sealing in the new state to a flattened seal in the run-in state, the hydraulically effective sealing diameter  $d_{hydr.}$  shifts from the original sealing edge into the

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wear region. This means that the original hydraulically effective sealing diameter  $d_{hydr.}$  decreases. The hydraulically effective sealing diameter  $d_{hydr.operation,DL}$  established in the run-in state with a flattened seal is less than the hydraulically effective sealing diameter  $d_{hydr.}$  in the new state, and as a result the hydraulically effective surface area changes. Because of a change in the hydraulically effective surface area in the valve seat region of the magnet valve, the force ratios engaging the valve needle change, which causes an unwanted change in the switching behavior of the magnet valve over its life and thus causes a quantity drift.

Page 3, please replace paragraph [0008] with the following amended paragraph:

[0008] Summary of the Invention    **SUMMARY OF THE INVENTION**

Please replace paragraph [0009] with the following amended paragraph:

[0009] If the least possible quantity drift in the fuel quantity to be injected into the combustion chamber of an internal combustion engine over the service life is to be attained, the hydraulically effective sealing diameter  $d_{hydr.}$  must remain as constant as possible over the life of a valve. To achieve this, the valve seat, proposed according to the invention, of a magnet valve for use in high-pressure fuel injection systems has for example a double-cone or multiconical geometry, including undercuts. The design of a valve seat proposed according to the invention is distinguished by the fact that in the sealing region of the valve seat, the seat angle difference is reduced, and downstream of the sealing region (the free region) of the valve seat, the seat angle difference is increased. The double-cone or multiconical geometry, when the valve is new, leads to a flattened seal, that is, a flattened contact region, since the slight seat angle difference and roughness or tolerances in smoothness of the valve needle and

the valve body assure that not only will the outer edge of the valve needle rest on the valve body, but so will "roughness points", which originate in the machining, between the valve needle and the valve body. When the valve is new, accordingly, unlike the variant embodiments with a single cone known from the prior art, there is no linear sealing region (or sealing edge). Because of an increased seat angle difference in the free region, that is, downstream of the sealing region, a limitation of the ensuing mechanical wear can be achieved. By this provision, the hydraulically effective sealing diameter  $d_{hydr.}$  in the new state is reduced, and in the run-in state of the valve it is stabilized. Thus the hydraulically effective sealing diameter  $d_{hydr.}$  can be kept virtually constant over the life of the valve proposed according to the invention. As a result, a quantity drift in the fuel quantity injected into the combustion chamber of an internal combustion engine, and its variation over the life of the valve, can be reduced. Because of the essentially constant hydraulically effective sealing diameter  $d_{hydr.}$ , a change in the switching behavior of the valve, equipped with the seat geometry proposed according to the invention, can accordingly advantageously be maximally avoided.

Page 4, please replace paragraph [0010] with the following amended paragraph:  
[0010] The embodiment proposed according to the invention of a valve seat as a double-cone or multiconical geometry can advantageously be employed especially in high-pressure injection systems, of the kind used in self-igniting internal combustion engines, in which pressures of more than 1500 bar must remain capable of being mastered. The design proposed according to the invention of the valve seat can be employed in both inward-

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opening valves (I-valves) and outward-opening valves (O-valves). In an advantageous variant embodiment, because of conical faces extending on both sides of a sealing edge, if the sealing edge becomes worn the hydraulically effective sealing diameter  $d_{hydr.}$  is unchanged, since the seat adaptation that occurs in operation because of the flattening of the sealing edge simultaneously extends both radially inward and radially outward. As a result, from an originally linear sealing, over the course of the life of the valve, with increasing flattening of the sealing edge, a sealing face that becomes larger symmetrically on both sides is created, whose characteristic is a constant, hydraulically effective sealing diameter  $d_{hydr.}$

Page 5, please replace paragraph [0011] with the following amended paragraph:

[0011] Drawing      **BRIEF DESCRIPTION OF THE DRAWINGS**

Please replace paragraph [0012] with the following amended paragraph:

[0012] The invention is described in further detail below in conjunction with the ~~drawing~~  
**drawings, in which:**

Please delete paragraph [0013].

Please replace paragraph [0014] with the following amended paragraph:

[0014] Fig. 1[[,]] **is a fragmentary sectional view of** a variant embodiment of a double-cone seat geometry in an I-valve **in the seat region;**

Page 6, please replace paragraph [0024] with the following amended paragraph:

[0024] Variant Embodiments

**DESCRIPTION OF THE PREFERRED EMBODIMENTS**

Page 7, please replace paragraph [0027] with the following amended paragraph:

[0027] In the variant embodiment of the valve seat region 5 shown in Fig. 1, a sealing edge 8 is defined by the sealing edge diameter 25  $[(d_s)]$  of a first conical face 20 of a multiple cone 19. Inside the first conical face 20, a seat angle difference 18 is embodied. The seat angle difference 18 amounts to only a few degrees ( $\leq 5^\circ$ ). When the valve 1 is new, the sealing edge diameter 25  $[(d_s)]$  approximately coincides with the hydraulically effective sealing diameter 14  $d_{hydr,new}$ . Because of the seat angle difference 18 embodied at the first conical face 20, the contact between the sealing edge 8 and the seat face 29, over the course of operation, changes over into a ~~flattish~~ **flattened** contact, but because of the slight seat angle difference 18, it is assured that a hydraulically effective sealing diameter 15  $d_{hydr,operation}$  (dashed line in Fig.1), which is established over the course of the time in operation, essentially matches the hydraulically effective sealing diameter 14  $d_{hydr,new}$  of the valve when new. The second conical face 21, adjoining the first conical face 20, of the multiconical geometry 19 can be provided with a conical face whose angle is within an ~~annular~~ **angular** region 28 (see the illustration in Fig. 1). Because of the provision of the second conical face 21, which does not come into contact with the seat face 29 of the valve body 2, it is assured that the sealing action occurs only between the first conical face 20, embodied with the seat angle difference 18, and the seat face 29 of the valve body 2. As a result, the inlet width and closure width are limited.

Page 8, please replace paragraph [0028] with the following amended paragraph:

[0028] The angle of inclination, with which a second conical face 21 of the multiconical geometry 19 is embodied, can be within the range represented by the angle of inclination 28. The second conical face 21 of the multiconical geometry 19, below the second encompassing edge 12 on the valve needle 3, adjoins the first conical face 20 of the multiconical geometry 19. In cooperation with the seat face 29 of the valve body 2, in the closed state of the valve needle 3, both when the valve is new and in the state in which the valve needle 3 is fully run in, a ~~flattish~~ **flattened** sealing of the high-pressure region 6, where high pressure  $[[p_{HP}]]$  prevails, off from the low-pressure region 7, in which low pressure  $[[p_{LP}]]$  prevails, is achieved. In the view shown in Fig. 1, the outside diameter of the valve needle 3 is represented by reference numeral 24  $[[d_N]]$ .

Please delete paragraph [0030].

Please replace paragraph [0031] with the following amended paragraph:

[0031] **Fig. 2 shows a further variant embodiment of a valve seat region, proposed according to the invention, in an I-valve in which a**  $[[The]]$  high-pressure region 6, which is supplied via the high-pressure inlet 23, is separated from the low-pressure region 7, in which low pressure  $[[p_{LP}]]$  prevails, by the first conical face 20 of the valve needle 3.

Page 9, please replace paragraph [0034] with the following amended paragraph:

[0034] It can be seen from the illustration in Fig. 3 that the sealing edge 8, when the valve 1 is new, is embodied with the sealing edge diameter 25  $[[d_S]]$ . The sealing edge diameter 25  $[[d_S]]$ , when the valve 1 is new, corresponds to the hydraulically effective sealing diameter

$d_{hydr.new}$  (see reference numeral 14). The conical faces 20 and 21 of the multiconical geometry 19 extend on both sides of the sealing edge 8 in the valve seat region 5. The first conical face 20 of the multiconical geometry 19 is embodied with the seat angle difference 18, while the second conical face 21, which adjoins the first conical face 20 below the second encompassing edge 12, has a further seat angle difference 27, relative to the seat face 29 and the second conical face 21. Given a flattening that ensues in the course of operation in the region of the sealing edge 8 upon contact with the seat face 29, diametrically opposite, of the valve body 2, a seat adaptation occurs simultaneously both radially inward and radially outward, so that as the running in increases and with the ensuing wear, the hydraulically effective sealing diameter  $d_{hydr.operation}$  remains essentially unchanged. In the view shown in Fig. 3, the sealing edge 8 coincides with the second encompassing edge 12 of the valve needle 3.

Page 10, please delete paragraphs [0035] and [0037].

Please replace paragraph [0039] with the following amended paragraph:

[0039] The first conical face 20 is embodied with the seat angle difference 18, while the second conical face 21, below the second encompassing edge 12, on the valve needle 3 has a cone angle 27, which is greater than the seat angle difference 18 of the first conical face 20. In this case again, the sealing edge diameter 25  $[(d_s)]$  coincides with the outer diameter of the first conical face 20 of the multiconical geometry 19. The needle diameter 24  $[(d_N)]$  of the valve needle 3 simultaneously corresponds to the reference diameter of the valve body 2. With the variant embodiment shown in Fig. 5 of an I-valve 22 as well, a virtually constant

hydraulically effective sealing diameter when the valve is new can be achieved, compared to the state in which the valve seat has been run in.

Page 11, please replace paragraph [0040] with the following amended paragraph:

[0040] While in the variant embodiments of the invention in Figs. 1 through 5, I-valve seats 22 have been described, that is, valves that open inward, ~~[[,]] in the variant embodiments sketched below~~; O-valves will be described **with reference to Figs. 6 through 10**. In the I-valves identified by reference numeral 22, the valve needle 3 opens in the direction of the high-pressure inlet 23 and enables a fluidic communication between the high-pressure region 6 and the low-pressure region 7. By comparison, **in** the variant embodiments described below in conjunction with Figs. 6 through 10 ~~involve O-valves, in which~~ the valve needle 3 opens away, or in other words outward, relative to the high-pressure inlet 23 into the high-pressure region 6.

Please replace paragraph [0042] with the following amended paragraph:

[0042] The magnet valve 1 shown in Fig. 6 includes the valve body 2, on which the seat face 29 is embodied. Via a high-pressure inlet 23 that penetrates the valve body 2 of the magnet valve 1, fuel at high pressure flows to the high-pressure region 6, in which high pressure ~~[[p<sub>HP</sub>]]~~ prevails. The valve needle 3 of the magnet valve 1 is constructed symmetrically to the line of symmetry 4. A first encompassing edge of the outward-opening valve needle 3 is identified by reference numeral 32, while a further, second encompassing edge of the outward-opening valve needle 3 is identified by reference numeral 33. In the valve seat region 5, diametrically ~~opposite~~ **opposed to** the seat face 29 of the valve body 2, the



multiconical geometry 19 is embodied, which includes both a first conical face 20 and a second conical face 21. The first conical face 20 of the multiconical geometry 19 is embodied with the seat angle difference 18, while the second conical face 21, which adjoins the first conical face 20 along the first encompassing edge 32 of the valve needle 3, is embodied with a cone angle 27 that is greater than the seat angle difference 18. In the open state, shown in Fig. 6, of the outward-opening valve needle 3, the high-pressure region 6 and the low-pressure region 7, in which low pressure  $[[p_{LP}]]$  prevails, communicate with one another. The sealing edge diameter 25  $[[d_s]]$  is largely equivalent to the hydraulically effective sealing diameter  $d_{hydr,new}$  14 in the new state of the valve 1. While the first conical face 20 of the multiconical geometry 19 is embodied with a seat angle difference 18, the second conical face 21 extends with a further seat angle difference 27, which is selected to be greater than the seat angle difference 18 of the first conical face 20. As a result, the wearing region at the valve needle 3 is limited to the region between the sealing edge 8 and the first encompassing edge 32 of the outward-opening valve needle 3. This region (see reference numeral 9) identifies the inlet/closure region between the seat face 29 on the valve body 2 and the first conical face 20 of the multiconical geometry 19.

Page 13, please delete paragraph [0044].

Please replace paragraph [0045] with the following amended paragraph:

[0045] Unlike the variant embodiment shown in Fig. 6 of the design proposed according to the invention of the valve seat region 5, **in the embodiment of Fig. 7** a recess configured in pocketlike fashion is located on the valve body 2. Inside the recess of the valve body 2, into

which the high-pressure inlet 23 discharges, the sealing edge 8 is embodied at the seat face

29. In the variant this embodiment shown in Fig. 7 as well of the valve seat region 5, ~~proposed according to the invention~~, on the magnet valve 1, the sealing edge 8 is located facing the first conical face 20. The first conical face 20 of the multiconical geometry 19 extends with the seat angle difference  $[[18]]$  18a relative to the seat face 29 of the valve body 2. The first encompassing edge 32 of the outward-opening valve needle 3 of the magnet valve 1 is adjoined by the second conical face 21 of the multiconical geometry 19, which in comparison to the first conical face 20 is embodied with the cone angle  $[[\alpha]]27[\alpha]$ . The first conical face 20 forms a sealing face  $[[17]]$ , while conversely the second conical face 21 of the multiconical geometry 19, because of the larger cone angle 27, represents a free face for limiting wear.

Please replace paragraph [0046] with the following amended paragraph:

[0046] Because of the embodiment of a pocket in the high-pressure region 6 between the valve body 2 and the valve needle 3, the diameter  $[[d_N]]$  24 of the valve needle 3 and the seat diameter  $[[d_s]]$  25 do not coincide in the variant embodiment of Fig. 7; instead, the seat diameter  $[[d_s]]$  25 exceeds the needle diameter  $[[d_N]]$  24 of the valve needle 3. By comparison to the variant embodiment of the O-valve 37 shown in Fig. 6, in the variant embodiment in Fig. 7 the sealing edge 8 is shifted outward by the amount of the pocket depth in the valve body 2, so that in comparison to the variant embodiment of Fig. 6, a greater seat diameter  $[[d_s]]$  25 ensues.

Page 14, please replace paragraph [0047] with the following amended paragraph:

[0047] In the new state of the valve 1, the hydraulically effective sealing diameter  $d_{hydr,new}$  of the valve coincides approximately with the sealing edge diameter 25  $[(d_s)]$ . Over the course of operation of the valve, the hydraulically effective sealing diameter **15**  $[[25]]$   $d_{hydr,operation}$  conversely shifts only insignificantly, as indicated by dashed lines in Fig. 7.

Please replace paragraph [0048] with the following amended paragraph:

[0048] In the variant embodiment shown in Fig. 7 of an O-valve 37, the sealing edge 8 is located facing approximately the middle of the first conical face 20 of the multiconical geometry 19, which has the seat angle difference  $[[18]]$  **18a**. The first conical face 20 of the multiconical geometry 19 functions as a sealing face, while the second conical face 21 with the seat angle difference 27, relative to the seat face 29 of the valve body 2, serves as a free face.

Please replace paragraph [0050] with the following amended paragraph:

[0050] Unlike the variant embodiments of Figs. 6 and 7, referring to an O-valve 27 and in which the seat face 29 extends continuously, in the variant embodiment shown in Fig. 8 a chamfer 38 on the seat face 29 is provided, which is inclined by an angle **18** to the seat face 29. The transition from the seat face 29 to the chamfer 38 forms the sealing edge on the valve body 2. Analogously to the multiconical geometries on the valve needle 3 shown in Figs. 6 and 7, the valve needle 3 shown in Fig. 8 is embodied with the first conical face 20 and the second conical face 21, which have cone angles 18 and 27, respectively, that differ from one another; that is, the seat angle difference  $[[18]]$  **18a** and the angle difference 27 of the first conical face  $[[21]]$  **20**. The sealing edge diameter 25  $[(d_s)]$  is identical to the hydraulically

effective sealing diameter  $d_{hydr,new}$  in the new state. Over the course of operation, the inlet/closure region propagates both radially inward and radially outward, so that the hydraulically effective sealing diameter  $d_{hydr,operation}$  remains constant.

Page 15, please replace paragraph [0052] with the following amended paragraph:

[0052] In the position shown in Fig. 8 of the valve needle 3 in the valve body 2, the high-pressure inlet 23, which discharges into the high-pressure region 6, and the low- pressure region 7, in which low pressure  $[[p_{LP}]]$  prevails, communicate with one another, so that via the high-pressure inlet 23, fuel flows via the high-pressure region 6 into the low-pressure region 7 of the magnet valve 1.

Page 16, please delete paragraph [0053].

Please replace paragraph [0054] with the following amended paragraph:

[0054] **Fig. 9 shows a further variant embodiment of an outward-opening valve needle in which the**  $[[The]]$  sealing edge 8 of the valve needle 3 is located in the first conical face 20 of the multiconical geometry 19 and is embodied with the seat angle differences 18 and 18a. Extending radially inward and radially outward, respectively, on either side of the sealing edge 8 relative to the valve needle 3, the first conical face 20 has seat angle differences 18 and 18a. If in operation of the outward-opening valve needle 3 of the O-valve 37 the sealing edge 8 strikes the seat face 29 of the valve body 2, then because of the seat angle differences 18 and 18a on both sides, the flattening of the sealing edge 8 extends symmetrically along the first conical face 20, or in other words symmetrically radially

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outward as well as symmetrically radially inward. As a result, in operation of the magnet valve 1, a uniformly extending flattening at the sealing edge 8 is achieved. The limitation of the inlet/closure region 9, in the variant embodiment shown in Fig. 9 of the valve seat region 5 proposed according to the invention, is effected as a result of the fact that the second conical face 21 of the multiconical geometry 19 has a more-acute cone angle than the first conical face 20.

Please replace paragraph [0055] with the following amended paragraph:

[0055] In the new state of the valve 1, in the variant embodiment of Fig. 9, the diameter 25 of the sealing edge 8 at the valve needle 3 and the hydraulically effective sealing diameter  $d_{hydr,new}$ -14 coincide. Over the course of operation, a hydraulically effective sealing diameter  $d_{hydr,operation}$  [[15]] ensues, which differs only insignificantly from the hydraulically effective sealing diameter 14 in the new state of the valve 1.

Page 17, please replace paragraph [0056] with the following amended paragraph:

[0056] The boundary of the second conical face 21, acting as a free face, of the multiconical geometry 19 of the valve needle 3 is formed by the second encompassing edge [[32]] 33 of the outward-opening valve needle 3. In the position of the valve needle 3 of Fig. 9, the high-pressure inlet 23 of the valve body 2, the high-pressure region 6 in which high pressure  $[[p_{HP}]]$  prevails, and the low-pressure region 7 in which low pressure  $[[p_{LP}]]$  prevails, communicate fluidically with one another.

Please delete paragraph [0057].

Please replace paragraph [0058] with the following amended paragraph:

[0058] **Fig. 10 finally shows a variant embodiment of an O-valve with a pocket embodied in the seat face of the valve body.** In the variant **this** embodiment of the valve seat region 5 ~~according to the invention shown in Fig. 10~~, the seat face 29 of the valve body 2 has a recess 36 configured in pocketlike fashion.

Please replace paragraph [0059] with the following amended paragraph:

[0059] The pocket 36[[,]] ~~which is embodied in the seat face 29 of the valve body 2~~, has the function of limiting the inlet/closure region 9 to the region between the sealing edge 8 at the valve body 2 and the first conical face 20 of the multiconical geometry 19. The same function at the valve needle 3 is performed by the second conical face 21 of the multiconical geometry 19, since the cone angle of the second conical face 21 has a more-acute course than that of the first conical face 20.

Page 18, please replace paragraph [0062] with the following amended paragraph:

[0062] In the new state of the outward-opening valve 37 shown in Fig. 10, the hydraulically effective sealing diameter 14  $d_{hydr,new}$  ~~(see reference numeral 14)~~ coincides with the diameter of the sealing edge 8 in the valve body 2. The hydraulically effective sealing diameter 15  $d_{hydr,operation}$  ~~(see reference numeral 15)~~ that ensues after sometime in operation differs only insignificantly from the hydraulically effective sealing diameter 14  $d_{hydr,new}$  of the outward-opening valve 37, so that even after relatively long operation of the outward-opening valve 37, no impermissible forces that adversely affect the closing and opening behavior of the outward-opening valve 37 can be caused by the change in hydraulic surface areas. As a

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result, the replicability both of injection quantities and of the instants of opening and closing is assured.

Please add the following new paragraph after paragraph [0062]:

[0063] The foregoing relates to a preferred exemplary embodiment of the invention, it being understood that other variants and embodiments thereof are possible within the spirit and scope of the invention, the latter being defined by the appended claims.

Please delete pages 19 and 20.